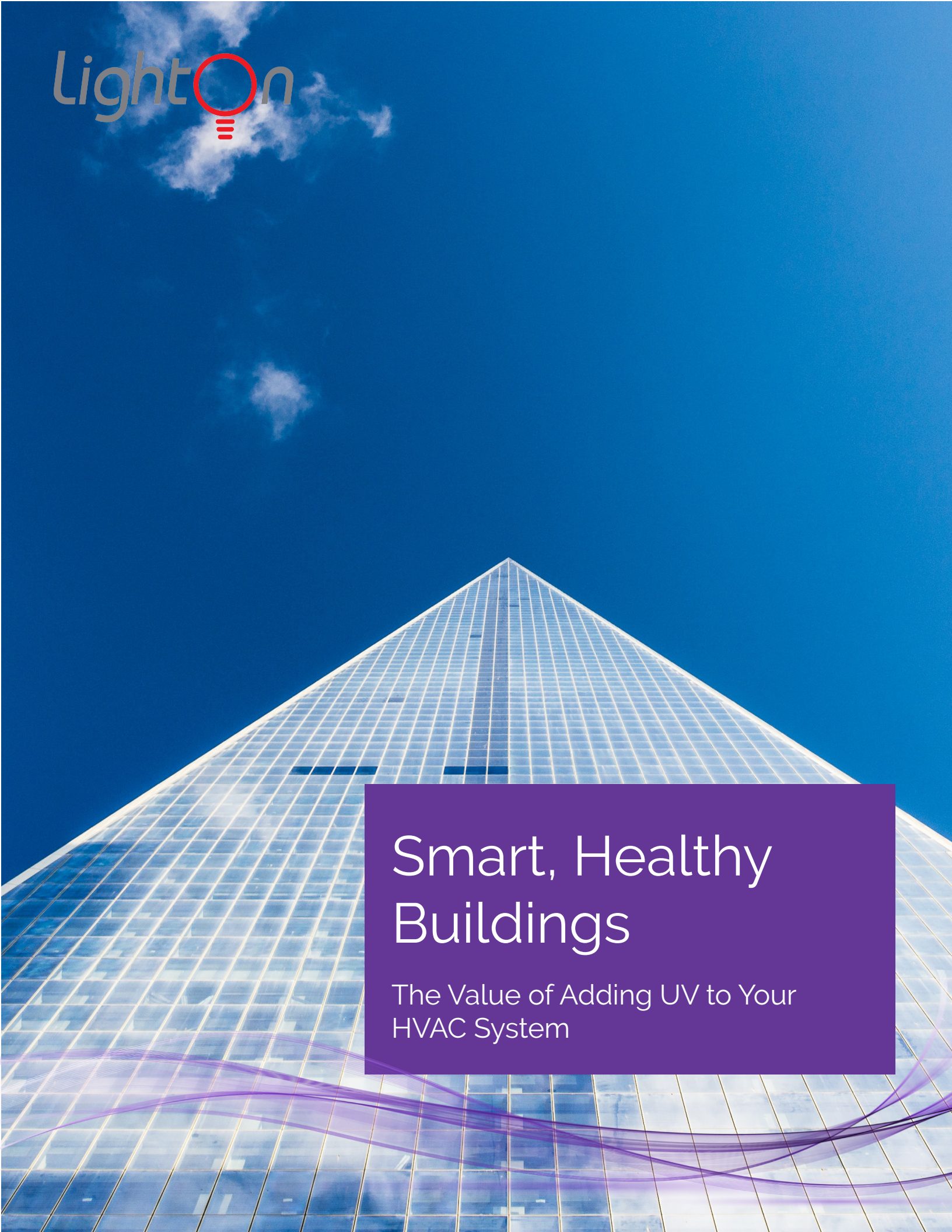


Smart, Healthy Buildings

The Value of Adding UV to Your HVAC System

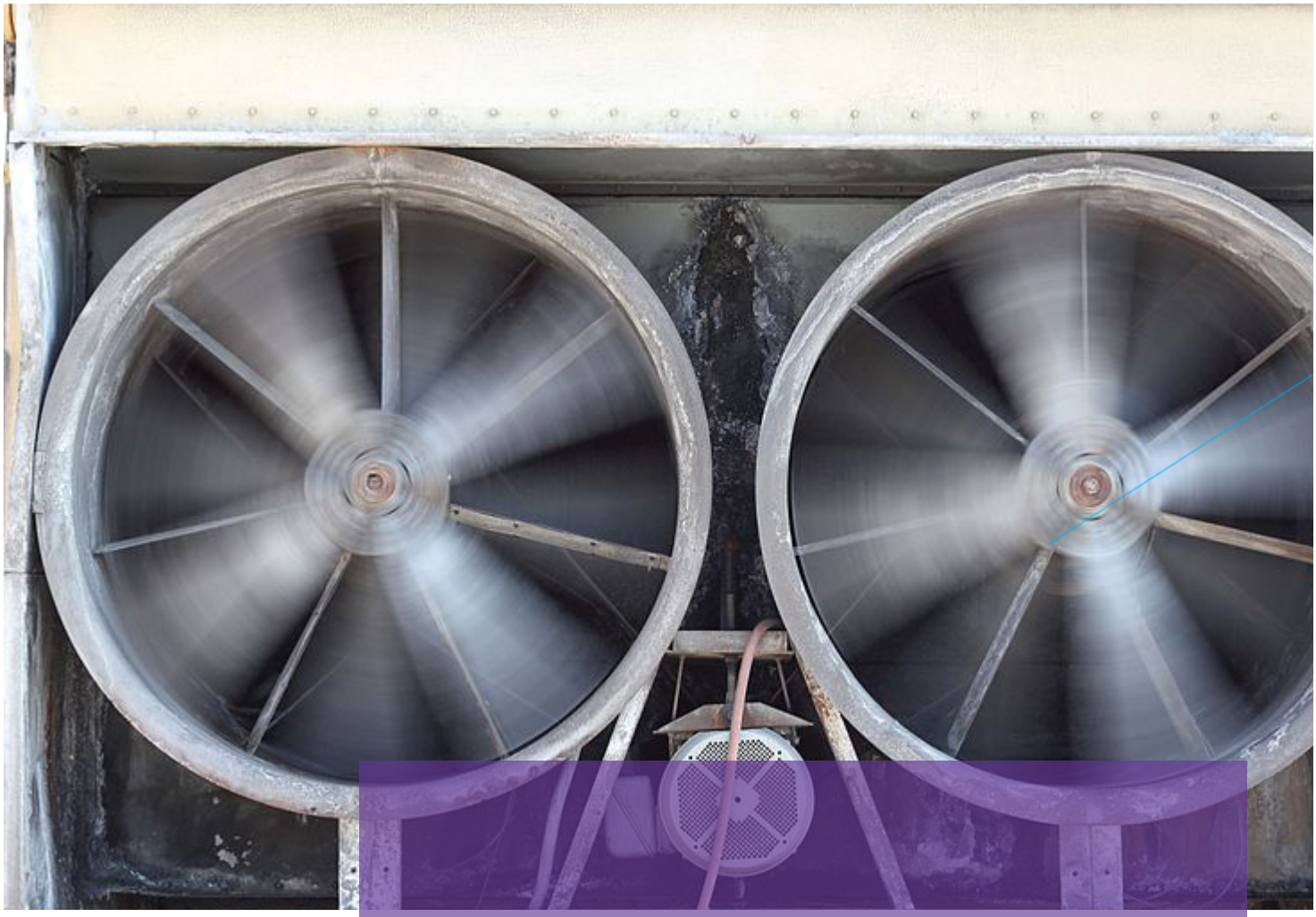


Table of Contents

Introduction

The benefits of ultraviolet light against harmful pathogens, including bacteria, viruses, mold and fungi have been known for over 100 years. It has been deployed in hospitals, schools, and many other locations for decades to help protect environments from germs.

While many of the traditional deployments of UV focused on surface decontamination or in upper-room air disinfection units, UV has also gained traction in the HVAC industry, as it can both help reduce microbial contamination in the air and improve the cooling efficiency of these systems.

This white paper lays out the case for why industry experts and professional organizations have endorsed UV as an effective tool for use in HVAC systems, and the value that will be added in both improved air quality and cost savings from improved efficiencies.

The Need for UV Disinfection

Over the past couple of decades, there has been increased demand for improved air quality, particularly in buildings such as schools and hospitals that often house vulnerable populations. The Institute of Medicine has found evidence connecting mold exposure with respiratory illnesses in otherwise healthy children.[1] Facility managers are tasked with helping protect the air quality in the HVAC systems to prevent mold and other contaminants from ending up in the air that occupants breathe.

A combination of moisture and dark interiors of HVAC systems make it an optimal place for the growth of mold and other harmful pathogens. Furthermore, pathogens, including bacterial spores can be introduced by occupants when they cough or sneeze and the contaminated particles travel in the airstream back to the air handler.

Mold and fungus can build up on coils and other HVAC surfaces, including forming biofilms that may not always be visibly detectable. This buildup can also stop or plug up the drains of condensate drip pans, which can lead to additional issues, such as water overflows and pungent odors.[2]

> "Biofilms on the surface of the cooling coils are like wearing a sweater when trying to cool down."
>
> *Lynn Burkhart, President & Founder of Controlled Release Technologies*

While chemical cleaning can be effective, albeit labor-intensive, the use of caustic chemicals may negatively impact the coils or drain pans if not properly rinsed off after use, including corrosion to the point of requiring premature replacement. According to industry experts, "costs to replace units prematurely corroded from frequent exposure to cleaning chemicals were approximately $5,000 each."[3]

As an alternative to chemical decontamination, ultraviolet light has been used in air ducts and air-handling units for some time to help control microbial growth. According to the National Air Duct Cleaners Association (NADCA), "one of the tools used to improve air quality from HVAC systems is the use of ultraviolet lighting within the system, intended to decrease the level of airborne pathogens and allergens going through the HVAC system and

thus into the indoor air environment."[4] Research has also linked the use of UV with improved performance and efficiency of the air-handling systems.

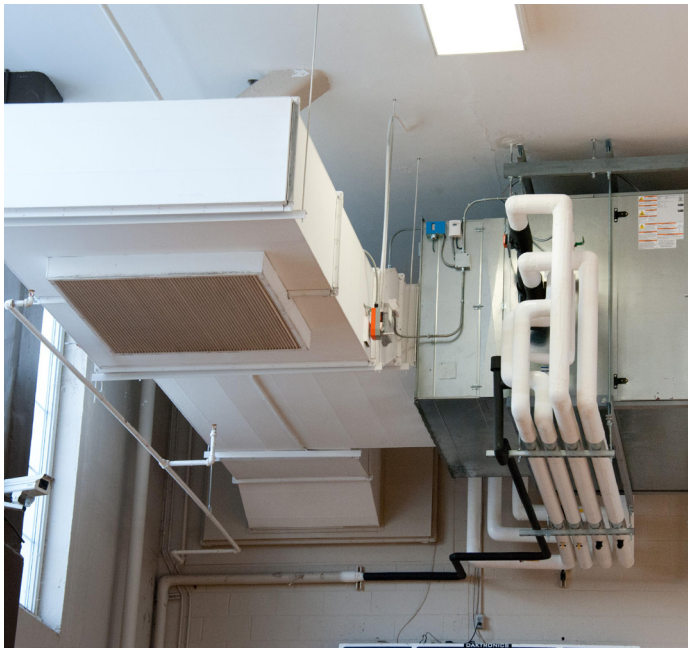
While not a "new" disinfecting technology, UV light has rapidly been growing in use in hospital settings as it is a proven disinfectant for surfaces, instruments, and air. With over 140 years of research behind it, UV light has been proven effective at killing bacteria, viruses, mold, and fungi.

Ultraviolet light attacks microorganisms at the DNA and RNA level. Microbes are not able to develop resistance to ultraviolet light, compared to their ability to form resistance to certain types of chemical disinfectants.

Ultraviolet light has been repeatedly proven effective against pathogens, including C. *diff*, MRSA, E. *coli*, Salmonella, Norovirus, mold and fungi. The ability of UV light to kill microorganisms is directly related to the energy dosage produced by the UV source as a function of spectrum, time and distance to the target.

The Return On Your Investment

Quantifying the exact benefits of improving air quality achieved by incorporating UV into air-handling systems can be challenging, though research has shown significant reduction in work-related, self-reported acute health symptoms when a UV-C system was 'irradiating cooling coils and drain pants, compared to when it was powered off."[5]



However, the economic impact of restoring the coils to their optimal condition can be calculated much more easily. Studies conducted by ASHRAE have indicated that building owners could be paying up to 40% more in electrical costs for units fouled with dirt and fungi.[1]

When the coils become fouled with contaminants, the ability for the units to efficiently or adequately transfer heat becomes significantly hindered, causing the compressor to have to work harder. A combination of more heat in the system and rising pressure can result "in a loss of cooling capacity of up to 30%. A 10-ton system with a 30% loss provides only 7 tons of cooling."[2] Thin biofilms on coil surfaces have been shown to reduce the free area of heat transfer and increase air velocity by 9 percent.[6] All of these additional demands on the system can also reduce the equipment's life expectancy.

In 2008, the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) officially began to incorporate UV into its handbooks as a viable tool for use in HVAC systems. In the 2011 ASHRAE handbook, the organization formally set forth guidelines for how to effectively incorporate UV into air handlers to "1) eliminate mold and bacteria, 2) reduce and/or eliminate coil cleaning and 3) sustain coil performance."[7]

They did this on the back end of extensive research and application experience proving that "UV-C wavelength inactivates microorganisms living on HVAC air ducts and evaporator coils with a kill ratio of 90% or higher, depending on light intensity, length of exposure, lamp placement and lamp life cycle."[8]

ASHRAE also cited that mechanically cleaning the surfaces of HVAC equipment "can be costly, difficult to perform, and dangerous to maintenance staff and building occupants."[9]

Estimates indicate that the cost of implementing a UV disinfection system can pay for itself with energy savings generated, or replacing the costs associated with manual decontamination or part replacements caused by contaminated or corroded system parts. Preventing refrigerant leaks by reducing or eliminating biological corrosion can also save thousands of dollars.[6]

Technical Considerations

The ASHRAE handbook recommends that to achieve the desired goals of disinfection on the coiling coils, a UV dose of 50-100 $\mu W/cm^2$ should strike coil surfaces. This is frequently achieved by deploying a UV-C bulb continuously at a distance of 12 inches from the coils.[9] However, alternate deployment methods are acceptable if they can achieve the desired intensity across the areas to be disinfected.

While the majority of UV systems utilize UV-C exclusively, there are other product offerings on the market like those powered by Violet Defense's technology, that deploy a broad spectrum of UV light, including UV-C, UV-B, and UV-A. While UV-C is typically what's referred to as germicidal, UV-B has also been proven to be lethal to microbes. Furthermore, broad spectrum UV light can

inhibit photo-reactivation, the process that can result in self-repair of damaged microbes.

While much of the focus has been on disinfecting coils within air-handling units, UV has also been used to disinfect bioaerosols, or airborne particles that contain living organisms, in the airstream. UV-C can be used to "inactivate substantial fraction of environmental bioaerosols in a single pass of air through a duct."[10]

However, the Air-Conditioning and Refrigeration Technology Institute (ARTI) encourages users to "be extremely cautious regarding claims about UVGI systems' high levels of inactivation of pathogenic bioaerosols." The rate of airflow that may contain these organisms is so fast, up to hundreds or thousands of feet per minute, that it can be incredibly difficult to kill at this rate without substantial UV energy that has been proven to disinfect air in seconds or fractions of a second.[11]

While a UV system for airflow disinfection may be effective, extensive testing should be conducted to confirm it can achieve the targeted disinfection rates. Facility managers should evaluate their goals, both disinfection and cost-reduction, when deciding which UV deployment method will best meet their needs.

Conclusion

Incorporating UV into air-handling units to address microbial buildup on stationary parts such as coils, drip pans is a highly effective method to limit the growth of mold and other organisms, which has the cost-saving benefits described, as well as the ability to improve air quality for issues associated with dirty coils.

Ultraviolet light has an extensive history of effectively killing microbes in the air and on surfaces, which has been proven to reduce the infection rates of MRSA, C. *diff*, VRE and other harmful pathogens.

With its proven results and chemical-free method of disinfection, ultraviolet light provides a sustainable, effective way to help keep spaces, as well as HVAC systems free from harmful pathogens, including mold, fungi, bacteria and viruses.

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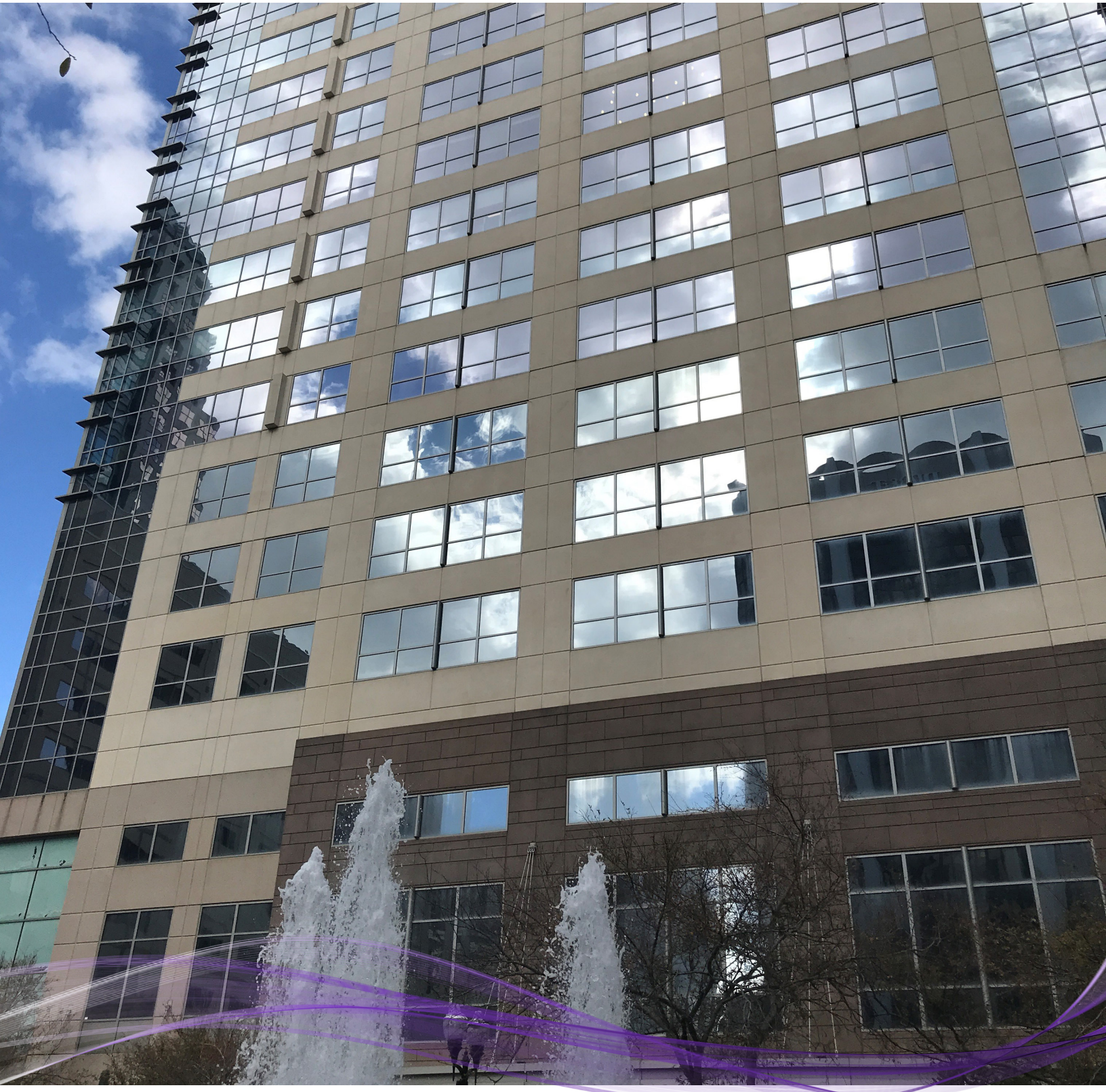

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